pH Biotelemetry Transmitter

John W. Hines, Michael G. Skidmore

Ames continued its development of pill-shaped biotelemeters for measuring physiological parameters during space life sciences experiments with the addition of a pH biotelemeter. These devices could eventually be used to monitor animal health parameters and the performance of self-contained biological systems aboard the International Space Station (ISS) Gravitational Biology Facility, and can be readily adapted to monitor the health of astronauts in the Human Research Facility. The equipment has enormous potential outside NASA as well.

A first prototype of an implantable pH biotelemeter has recently been developed (figure 1). This device can accurately measure pH in the range of 2 to 12, and the battery-powered transmitter has a range of approximately 6 feet and an expected lifetime of 6 months. The pH is measured by small, catheter-based ion-selective electrodes that are connected to an integrated pH-meter and radio frequency (RF) transmitter that sends the measurement information to an external receiver and is displayed in real time by a LabVIEW program. The next development effort will be the miniaturization of the pH biotelemeter into a pill-sized device.

As an initial test, the device is currently being prepared for measurements of rumen pH in cattle at the University of California at Davis (UCD). Besides allowing NASA to test the performance of the biotelemeter in a large animal, this experiment gives doctors at UCD valuable information for nutritional management of dairy cattle.

NASA is interested in this technology for long-duration monitoring of research subjects in spaceflight. Astronauts and the life sciences experiments they oversee are in a remote and inaccessible environment. Their health and performance must be monitored as unobtrusively as possible so as not to interfere with ISS operations or with onboard experimental results. The pill-sized biotelemeters have direct application to plant and animal experiments where the device can be inserted, implanted, or ingested to obtain optimum information in situ. The same biotelemetry electronics, configured in a Band-Aid® arrangement with lightweight, flat polymer batteries, could be applied externally for noninvasive monitoring of astronaut health.

There are numerous possible future commercial applications of these new pill transmitters. Patients with digestive disorders could swallow a pH pill

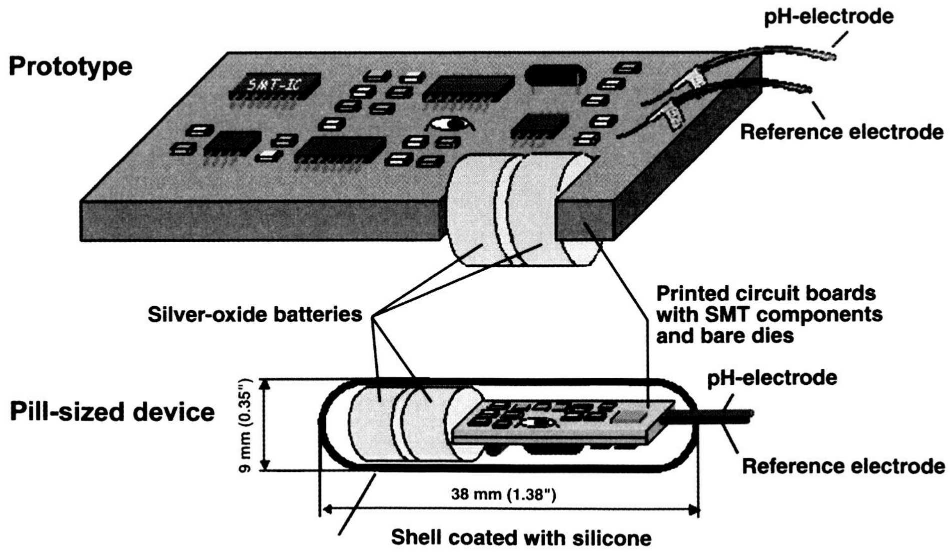

Fig. 1. The pH biotelemeter.

transmitter that monitors gastrointestinal acidity, or a pressure pill transmitter that gives data about contractions of intestinal smooth muscle, allowing doctors to better diagnose gastrointestinal problems. There is also great potential in sports medicine. Pill transmitters can monitor the performance and stress levels of athletes as they train. In addition, the military has expressed interest in similar devices to monitor the health and performance of soldiers in hostile environments.

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Physiologic Signal Conditioner for Crew Hazards and Error Management

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The Ames Research Center (ARC) Physiological Signal Conditioner (PSC) has been adapted to meet the requirements of the Crew Hazards and Error Management (CHEM) project of the Flight Dynamics and Controls Division at Langley Research Center. This new unit is an eight-channel physiologic signal processor designed to meet the need for human response measurement technologies. The purpose of these technologies is to assess an aircraft crew's ability to perform flight management tasks effectively in real or simulated stressful situations.

The PSC-CHEM, shown in the figure, processes biopotential signals, such as EEG, ECG, EMG, and others, as well as body temperature, respiration, and motion activity. The eight channels can be configured to measure any combination of these four signal types. The biopotential signals are sensed with self-sticking snap electrode patches. Cables snap onto the electrodes and have quick push-on/pull-off connectors for the PSC. Temperature sensors, motion sensors, and respiration bands have integral cables with push-on connectors for the PSC. All sensors can be attached to the crewmember independent of the PSC, and the PSC can be attached to the crew chair or to the crewmember if mobility is required while taking measurements.

The PSC is powered with internal rechargeable batteries. Processed physiologic signals are digitized for serial output, and the serial connection to a computer permits the user to view real-time signals. Custom software on the computer allows the user to interact with the PSC to adjust signal gain and filtering and allows the user to store the signals for later processing and review. For completely untethered operation, the serial cable is replaced with a telemetry interface. The telemetry system employs frequency hopping spread spectrum (FHSS) compatible with systems proposed for the International Space Station.

Future CHEM project requirements for additional physiologic or environmental parameters can be accommodated by the PSC-CHEM. Sensors and analog signal-processing circuitry would be developed to fit directly into the PSC and to conform to the user data-processing system. Also, as an operational system, the PSC-CHEM serves as a test platform to determine a baseline for some of the human factors requirements for a smaller, modular, wearable PSC for aviation and spaceflight applications.

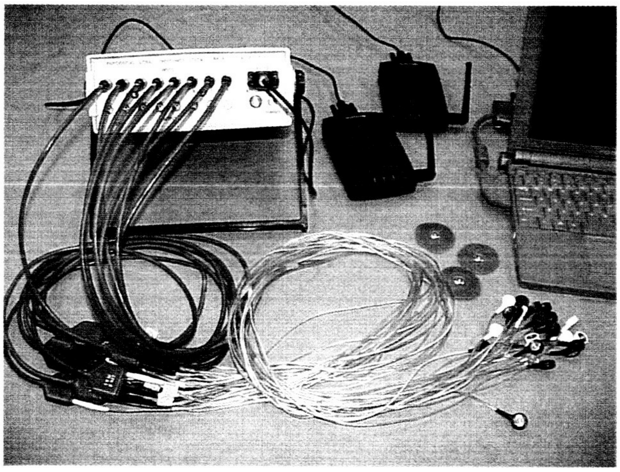

Fig. 1: Physiological Signal Conditioner for the Crew Hazards and Error Management Project (PSC-CHEM).

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